

Related Pending Application
Related Case Serial No: 10/060247
Related Case Filing Date: 02-01-02

WHAT IS CLAIMED IS:

1. A magnetoresistive device, comprising:
 - a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;
 - 5 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;
 - 10 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and
 - 15 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,
- wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of a binary alloy or a ternary alloy represented 20 by general formula (1) or (2) given below:

T_{1a}T_{2b} (1)

Fe_cCo_dNi_e (2)

where T₁ and T₂ are different from each other and selected from the group consisting of Fe, Co and Ni, 25 25 at% \leq a \leq 75 at%, 25 at% \leq b \leq 75 at%, and a + b = 100; and

0 < c \leq 75 at%, 0 < d \leq 75 at%, 0 < e \leq 63 at%,

and $c + d + e = 100$.

2. A magnetoresistive device, comprising:

a magnetization pinned layer of which

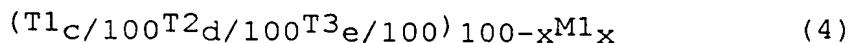
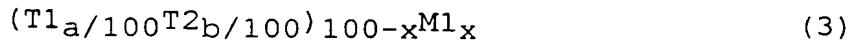
magnetization direction is substantially pinned to one
5 direction;

a magnetization free layer of which magnetization
direction is changed in accordance with an external
magnetic field;

10 a nonmagnetic intermediate layer formed between
the magnetization pinned layer and the magnetization
free layer; and

15 electrodes allowing a sense current to flow in
a direction substantially perpendicular to the plane of
the stack including the magnetization pinned layer, the
nonmagnetic intermediate layer and the magnetization
free layer,

20 wherein at least one of the magnetization pinned
layer and the magnetization free layer is formed of
an alloy represented by general formula (3) or (4)
given below:



25 where T_1 , T_2 and T_3 are different from each other
and selected from the group consisting of Fe, Co and
Ni; M_1 is at least one element selected from the group
consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga,
Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B,

Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F;

25 at% \leq a \leq 75 at%, 25 at% \leq b \leq 75 at%, and
a + b = 100;

5 5 at% \leq c \leq 90 at%, 5 at% \leq d \leq 90 at%,

5 at% \leq e \leq 90 at%, and c + d + e = 100; and
0.1 at% \leq x \leq 30 at%.

3. A magnetoresistive device, comprising:

a magnetization pinned layer of which

magnetization direction is substantially pinned to one
10 direction;

a magnetization free layer of which magnetization
direction is changed in accordance with an external
magnetic field;

15 a nonmagnetic intermediate layer formed between
the magnetization pinned layer and the magnetization
free layer; and

20 electrodes allowing a sense current to flow in
a direction substantially perpendicular to the plane of
the stack including the magnetization pinned layer, the
nonmagnetic intermediate layer and the magnetization
free layer,

25 wherein at least one of the magnetization pinned
layer and the magnetization free layer is substantially
formed of an alloy represented by general formula (5)
given below:



where Tl is at least one element selected from the

group consisting of Co, Cr, V, Ni, Rh, Ti, Mo, W, Nb, Ta, Pd, Pt, Zr and Hf; and

0 at% \leq a $<$ 70 atomic %;

and wherein the alloy has a body-centered cubic
5 crystal structure.

4. A magnetoresistive device, comprising
a magnetization pinned layer of which
magnetization direction is substantially pinned to one
direction;

10 a magnetization free layer of which magnetization
direction is changed in accordance with an external
magnetic field;

15 a nonmagnetic intermediate layer formed between
the magnetization pinned layer and the magnetization
free layer; and

20 electrodes allowing a sense current to flow in
a direction substantially perpendicular to the plane of
the stack including the magnetization pinned layer, the
nonmagnetic intermediate layer and the magnetization
free layer,

wherein at least one of the magnetization pinned
layer and the magnetization free layer is substantially
formed of an alloy represented by general formula (6)
given below:

25 $Fe_{100-a}T1_a$ (6)

where

0 at% \leq a \leq 80 at%, in the case where T1 is Co;

0 at% \leq a \leq 80 at%, in the case where Tl is Cr;
0 at% \leq a \leq 70 at%, in the case where Tl is V;
0 at% \leq a \leq 20 at%, in the case where Tl is Ni;
0 at% \leq a \leq 55 at%, in the case where Tl is Rh;

5 and

0 at% \leq a \leq 51 at%, in the case where Tl is Ti;
and wherein the alloy has a body-centered cubic
crystal structure.

5. A magnetoresistive device, comprising:

10 a magnetization pinned layer of which
magnetization direction is substantially pinned to one
direction;

15 a magnetization free layer of which magnetization
direction is changed in accordance with an external
magnetic field;

a nonmagnetic intermediate layer formed between
the magnetization pinned layer and the magnetization
free layer; and

20 electrodes allowing a sense current to flow in
a direction substantially perpendicular to the plane of
the stack including the magnetization pinned layer, the
nonmagnetic intermediate layer and the magnetization
free layer,

25 wherein at least one of the magnetization pinned
layer and the magnetization free layer is formed of a
ternary alloy selected from the group consisting of an
Fe-Co-Ni alloy, a Co-Mn-Fe alloy and an Fe-Cr-Co alloy;

and wherein the ternary alloy has a body-centered cubic crystal structure.

6. A magnetoresistive device, comprising:

a magnetization pinned layer of which

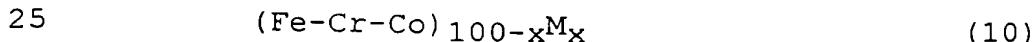
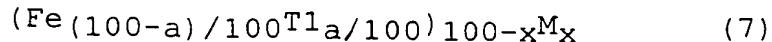
5 magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

10 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

15 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially 20 formed of an alloy represented by any of general formulas (7) to (10) given below:



where $T1$ is at least one element selected from the group consisting of Co, Cr, V, Ni, Rh, Ti, Mo, W, Nb,

Ta, Pd, Pt, Zr and Hf, and 0 at% \leq a < 70 atomic %;

the Fe-Co-Ni alloy is in a composition region forming a body-centered cubic crystal;

5 the Co-Mn-Fe alloy is in a composition region forming a body-centered cubic crystal structure;

the Fe-Cr-Co alloy is in a composition region forming a body-centered cubic crystal structure;

10 0.1 at% \leq x \leq 20 at%, in the case where M is at least one element selected from the group consisting of Mn, Cu, Re, Ru, Pd, Pt, Ag, Au and Al; and

0.1 at% \leq x \leq 10 at%, in the case where M is at least one element selected from the group consisting of Sc, Zn, Ga, Ge, Zr, Hf, Y, Tc, B, In, C, Si, Sn, Ca, Sr, Ba, O, F and N;

15 and wherein the alloy has a body-centered cubic crystal structure.

7. A magnetoresistive device, comprising:

20 a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

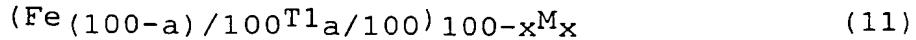
a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

25 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in

a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

5 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (11) given below:



10 where

0 at% \leq a \leq 80 at%, in the case where Tl is Co;

0 at% \leq a \leq 80 at%, in the case where Tl is Cr;

0 at% \leq a \leq 70 at%, in the case where Tl is V;

0 at% \leq a \leq 10 at%, in the case where Tl is Ni;

15 0 at% \leq a \leq 55 at%, in the case where Tl is Rh;

0 at% \leq a \leq 51 at%, in the case where Tl is Ti;

0.1 at% \leq x \leq 20 at%, in the case where M is at least one element selected from the group consisting of Mn, Cu, Re, Ru, Pd, Pt, Ag, Au and Al; and

20 0.1 at% \leq x \leq 10 at%, in the case where M is at least one element selected from the group consisting of Sc, Zn, Ga, Ge, Zr, Hf, Y, Tc, B, In, C, Si, Sn, Ca, Sr, Ba, O, F and N;

25 and wherein the alloy has a body-centered cubic crystal structure.

8. A magnetoresistive device, comprising:

 a magnetization pinned layer of which

magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external
5 magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

10 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

15 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (12) given below:

$$(Fe_{(100-a)/100}T1a/100)_{100-x}M_x \quad (12)$$

20 where T1 is at least one element selected from the group consisting of Co and Ni, and 0 at% \leq a \leq 50 at%; and

25 M is at least one element selected from the group consisting of Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% \leq x \leq 30 at%.

9. A magnetoresistive device, comprising:

a magnetization pinned layer of which

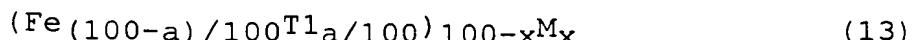
magnetization direction is substantially pinned to one direction;

5 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

10 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

15 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (13) given below:



20 where Tl is at least one element selected from the group consisting of Co and Ni, and $0 \text{ at\%} \leq a \leq 50 \text{ at\%}$; and

M is at least one element selected from the group consisting of Cu, Zn and Ga, and $0.1 \text{ at\%} \leq x \leq 30 \text{ at\%}$.

10. A magnetoresistive device, comprising:

25 a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

5 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

10 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

15 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (14) given below:



where M is at least one element selected from the group consisting of Co and Ni, and $0.1 \text{ at\%} \leq x \leq 5 \text{ at\%}$.

20 11. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

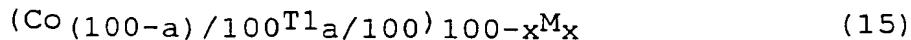
25 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between

the magnetization pinned layer and the magnetization free layer; and

5 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

10 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (15) given below:



15 where T1 is at least one element selected from the group consisting of Fe and Ni, and 0 at% \leq a \leq 50 at%; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 20 0.1 at% \leq x \leq 30 at%.

12. A magnetoresistive device, comprising:

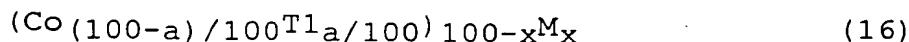
a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

25 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

5 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

10 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (16) given below:



15 where $T1$ is at least one element selected from the group consisting of Fe and Ni, and $0 \text{ at\%} \leq a \leq 50 \text{ at\%}$; and

M is at least one element selected from the group consisting of Sc, Ti, Mn, Cu and Hf, and $0.1 \text{ at\%} \leq x \leq 30 \text{ at\%}$.

20 13. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

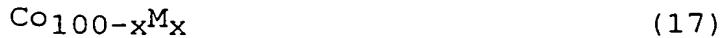
25 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between

the magnetization pinned layer and the magnetization free layer; and

5 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

10 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (17) given below:



15 where M is at least one element selected from the group consisting of Fe and Ni, and $0.1 \text{ at\%} \leq x \leq 5 \text{ at\%}$.

14. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

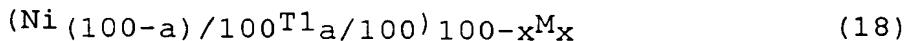
20 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

25 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of

the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

5 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (18) given below:



10 where Tl is at least one element selected from the group consisting of Co and Fe, and $0 \text{ at\%} \leq a \leq 50 \text{ at\%}$; and

15 M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and $0.1 \text{ at\%} \leq x \leq 30 \text{ at\%}$.

15. A magnetoresistive device, comprising:

20 a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

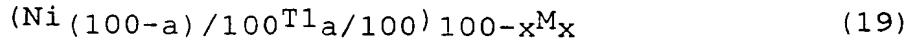
a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

25 the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in

a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

5 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (19) given below:



10 where $T1$ is at least one element selected from the group consisting of Fe and Co, and $0 \text{ at\%} \leq a \leq 50 \text{ at\%}$; and

15 M is at least one element selected from the group consisting of Sc, Ti, Mn, Zn, Ga, Ge, Zr and Hf, and $0.1 \text{ at\%} \leq x \leq 30 \text{ at\%}$.

16. A magnetoresistive device, comprising:

 a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

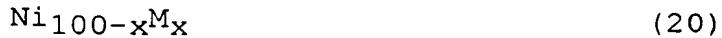
20 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

25 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of

the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

5 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (20) given below:



10 where M is at least one element selected from the group consisting of Fe and Co, and $0.1 \text{ at\%} \leq x \leq 5 \text{ at\%}$.

17. A magnetoresistive device, comprising:

15 a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

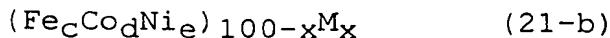
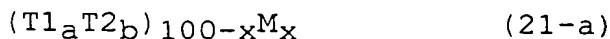
a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

20 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

25 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned

layer and the magnetization free layer is substantially formed of a binary alloy or a ternary alloy represented by general formula (21-a) or (21-b) given below:



where T1 and T2 are different from each other and selected from the group consisting of Fe, Co and Ni, $25 \text{ at\%} \leq a \leq 75 \text{ at\%}$, $25 \text{ at\%} \leq b \leq 75 \text{ at\%}$, and $a + b = 100$;

10 $0 < c \leq 75$ at%, $0 < d \leq 75$ at%, $0 < e \leq 63$ at%,
 and $c + d + e = 100$; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and $0.1 \text{ at\%} \leq x \leq 20 \text{ at\%}$.

18. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in

a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

5 wherein at least one of the magnetization pinned layer and the magnetization free layer has a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of an alloy represented by general formula (22-a) or
10 (22-b) given below:



where T_1 and T_2 are different from each other and selected from the group consisting of Fe, Co and Ni,
15 $25 \text{ at\%} \leq a \leq 75 \text{ at\%}$, $25 \text{ at\%} \leq b \leq 75 \text{ at\%}$, and
 $a + b = 100$; and

$0 < c \leq 75 \text{ at\%}$, $0 < d \leq 75 \text{ at\%}$, $0 < e \leq 63 \text{ at\%}$,
and $c + d + e = 100$; and

(ii) at least one layer formed of at least one
20 element selected from the group consisting of Cr, V,
Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re,
Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca,
Sr, Ba, O, N and F, and having a thickness falling
within a range of between 0.03 nm and 1 nm.

25 19. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetiza-
tion direction is substantially pinned to one

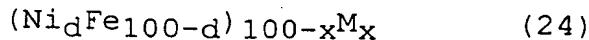
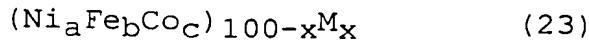
direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

5 a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

10 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

15 wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (23) or (24) given below:



20 where $0 < a \leq 75$ at%, $0 < b \leq 75$ at%, $0 < c \leq 75$ at%, and $a + b = 100$;

$75 \text{ at\%} \leq d \leq 85 \text{ at\%}$; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, 25 Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and $0.1 \text{ at\%} \leq x \leq 20 \text{ at\%}$.

20. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

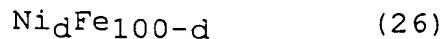
5 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

10 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

15 wherein at least one of the magnetization pinned layer and the magnetization free layer has a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of an alloy represented by general formula (25) or (26)
20 given below:



where $0 < a \leq 75$ at%, $0 < b \leq 75$ at%,
25 $0 < c \leq 75$ at%, and $a + b = 100$; and



(ii) at least one layer formed of at least one element selected from the group consisting of Cr, V,

Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and having a thickness falling within a range of between 0.03 nm and 1 nm.

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21. A magnetoresistive device, comprising:

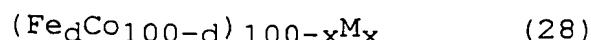
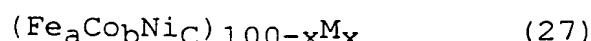
a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

10 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

15 electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

20 wherein the magnetization pinned layer is substantially formed of an alloy represented by general formula (27) or (28) given below:



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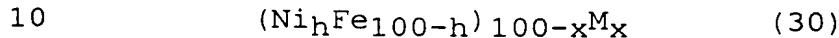
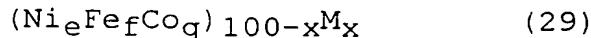
where $0 < a \leq 75$ at%, $0 < b \leq 75$ at%, $0 < c \leq 75$ at%, and $a + b = 100$;

45 at% $\leq d \leq 55$ at%; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and

5 0.1 at% \leq x \leq 20 at%,

and wherein the magnetization free layer is substantially formed of an alloy represented by general formula (29) or (30) given below:



where 60 at% \leq e \leq 75 at%, 12.5 at% \leq f \leq 20 at%, 12.5 at% \leq g \leq 20 at%, and e + f + g = 100; 75 at% \leq h \leq 85 at%; and

15 M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% \leq x \leq 20 at%.

22. A magnetoresistive device, comprising:

20 a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

25 a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

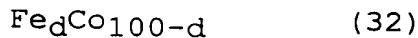
a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization

free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein the magnetization pinned layer has a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of an alloy represented by general formula (31) or (32) given below:



where $0 < a \leq 75$ at%, $0 < b \leq 75$ at%,

$0 < c \leq 75$ at%, and $a + b = 100$;

$45 \text{ at\%} \leq d \leq 55 \text{ at\%}$; and

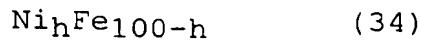
(ii) at least one layer formed of at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and having a thickness falling within a range of between 0.03 nm and 1 nm,

and wherein the magnetization free layer has

a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of

an alloy represented by general formula (33) or (34) given below:



5 where $60 \text{ at\%} \leq e \leq 75 \text{ at\%}$, $12.5 \text{ at\%} \leq f \leq 20 \text{ at\%}$, $12.5 \text{ at\%} \leq g \leq 20 \text{ at\%}$, and $e + f + g = 100$;
 $75 \text{ at\%} \leq h \leq 85 \text{ at\%}$; and

10 (ii) at least one layer formed of at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and having a thickness falling within a range of between 0.03 nm and 1 nm.

15 23. A magnetic head comprising the magneto-resistive device according to any of claims 1 to 22.

24. A magnetic recording-reproducing apparatus, comprising a magnetic recording medium, and the magneto resistive device according to any of claims 1 to 22.

ABSTRACT OF THE DISCLOSURE

A magnetoresistive device includes a magnetization pinned layer, a magnetization free layer, a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer, and electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer. At least one of the magnetization pinned layer and the magnetization free layer is substantially formed of a binary or ternary alloy represented by the formula $Fe_aCob_bNi_c$ (where $a + b + c = 100$ at%, and $a \leq 75$ at%, $b \leq 75$ at%, and $c \leq 63$ at%), or formed of an alloy having a body-centered cubic crystal structure.

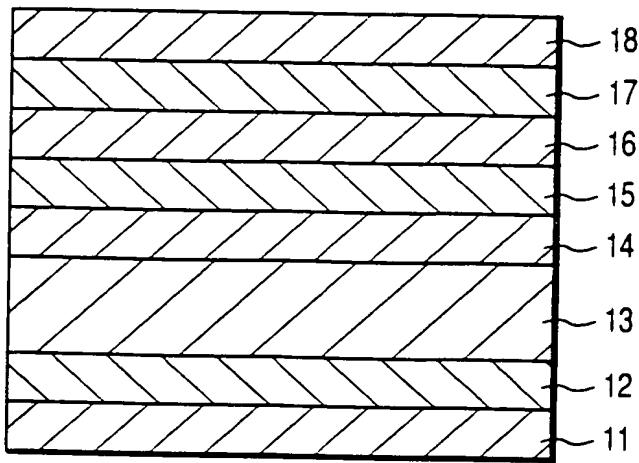


FIG. 1

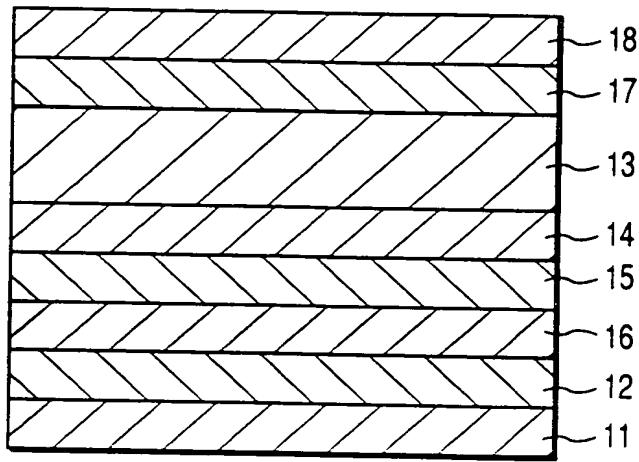


FIG. 2

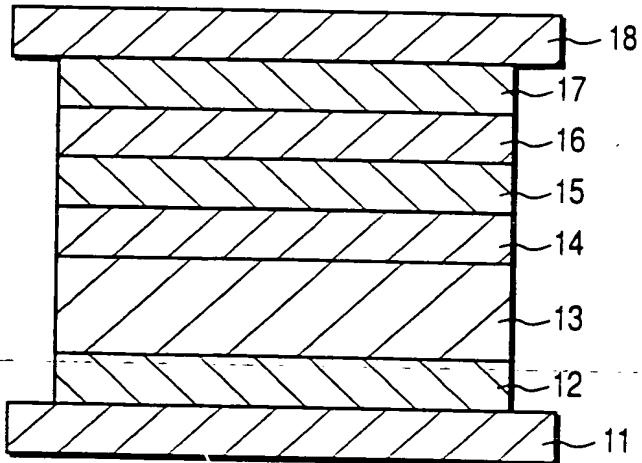


FIG. 3

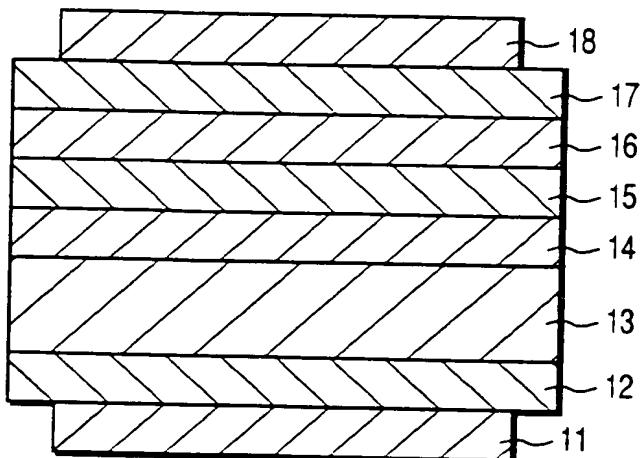
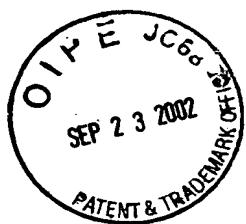


FIG. 4

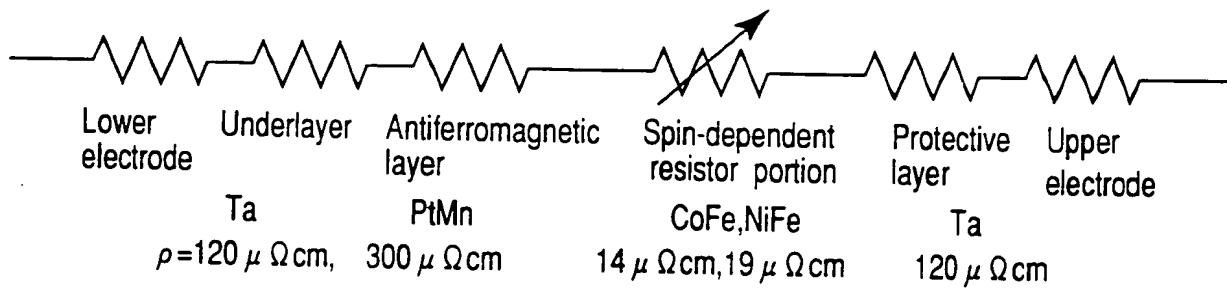


FIG. 5

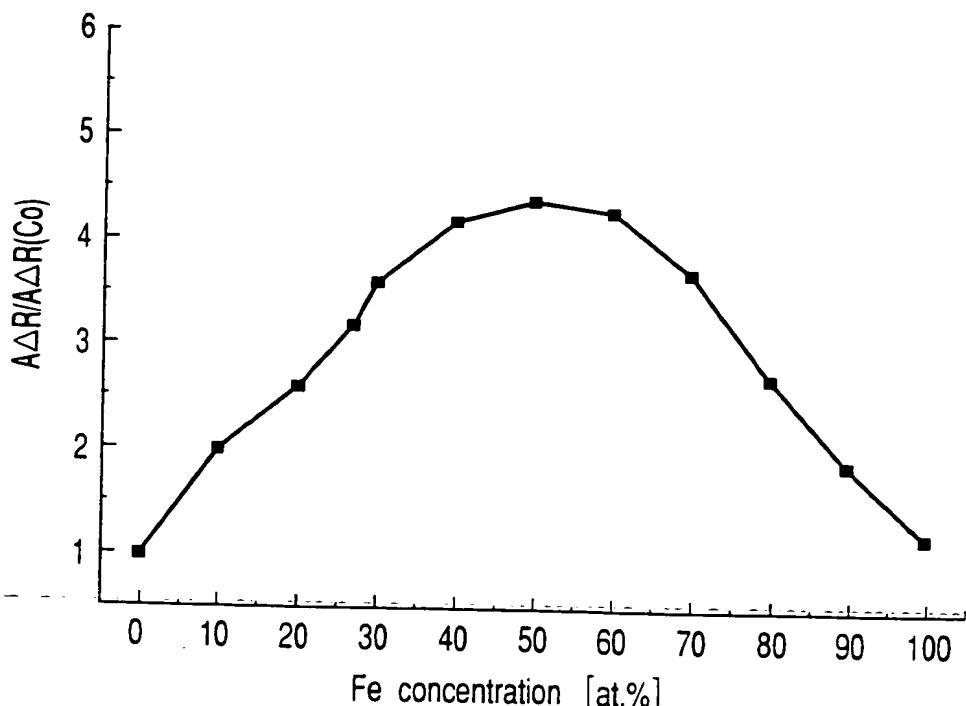


FIG. 6

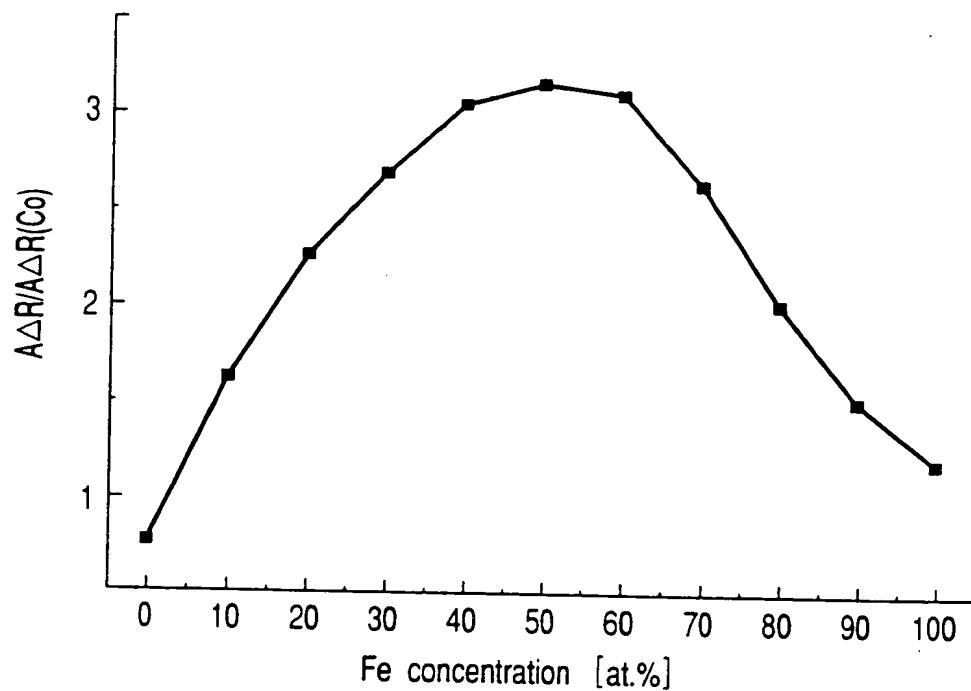
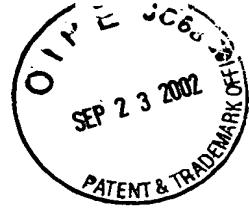


FIG. 7

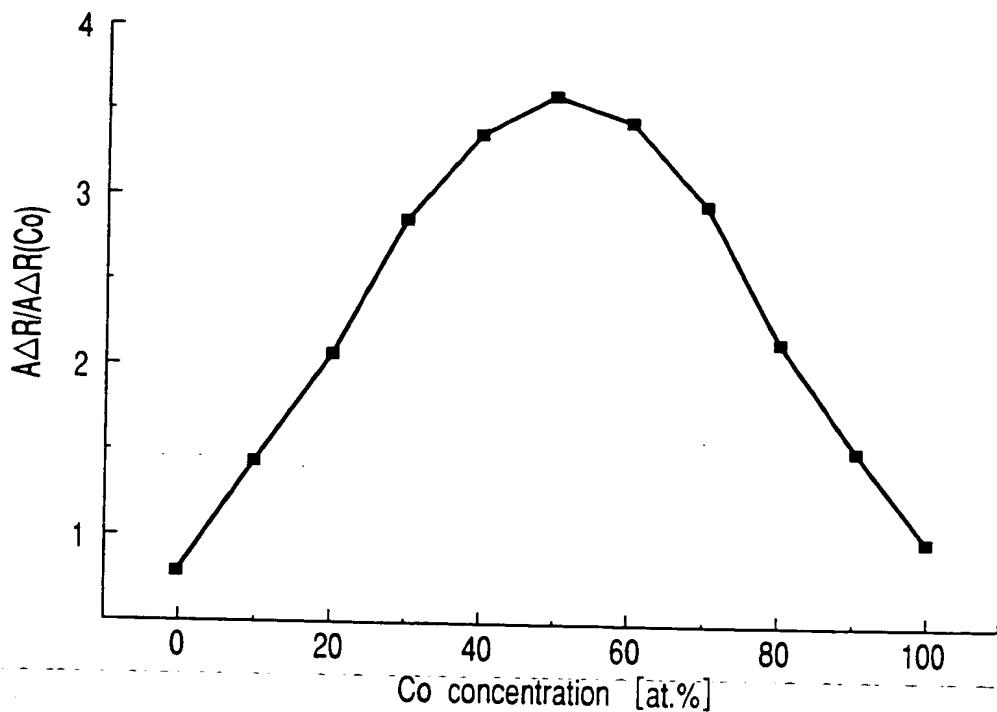


FIG. 8

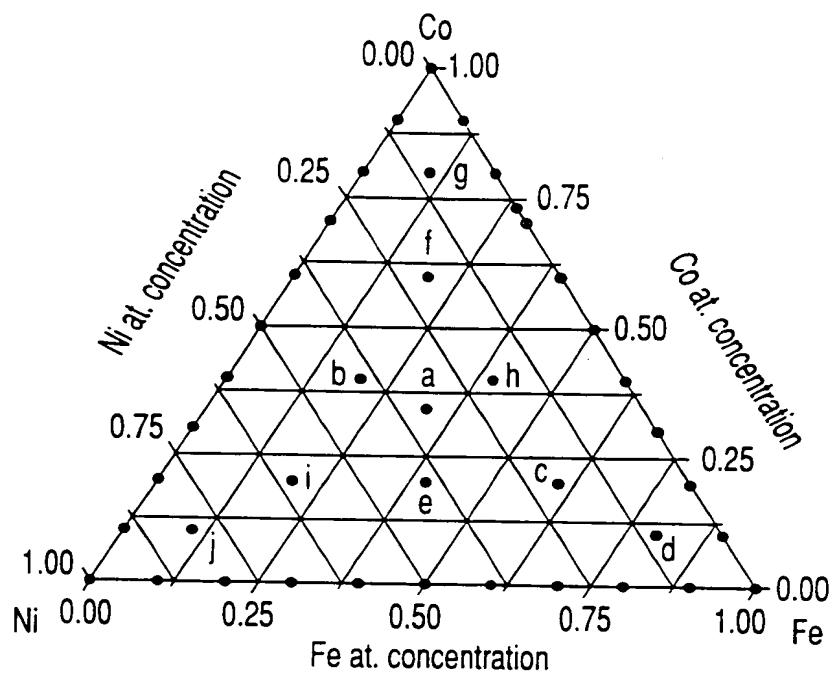
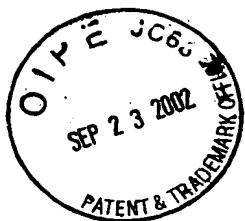


FIG. 9

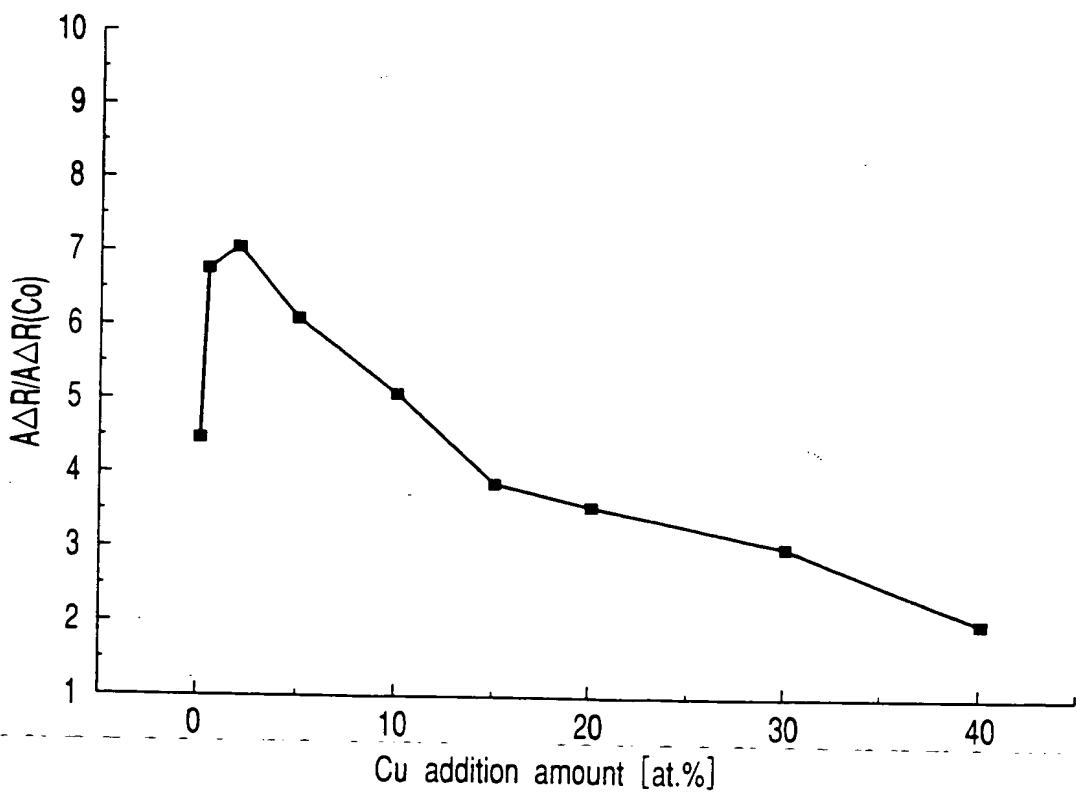
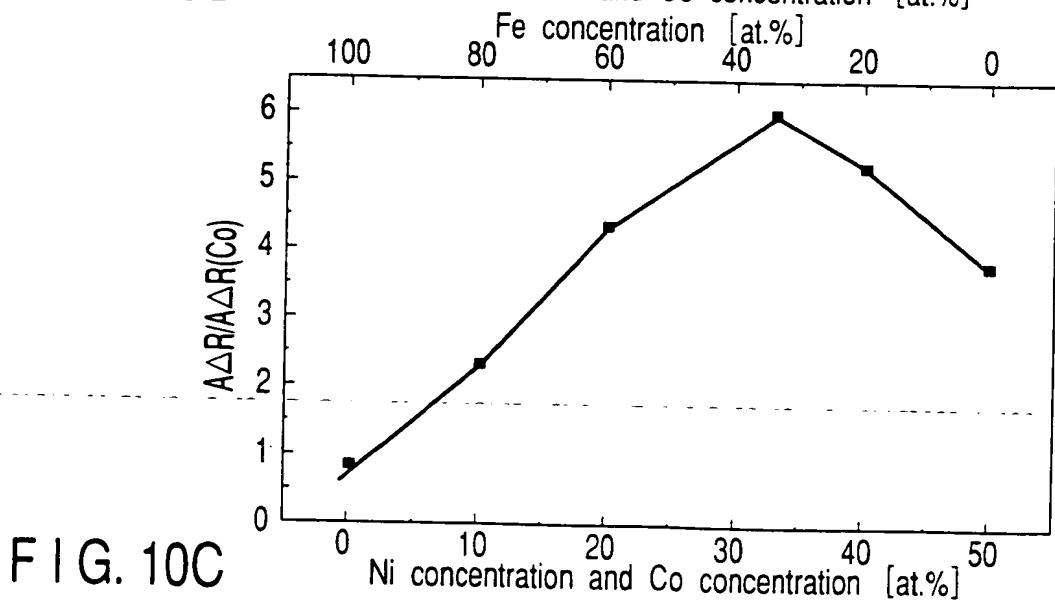
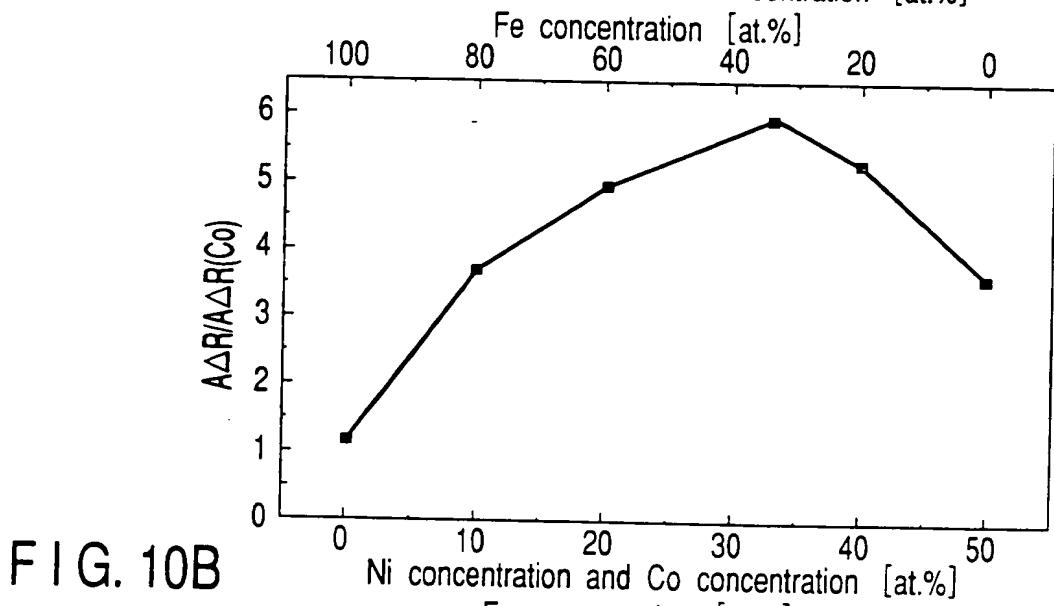
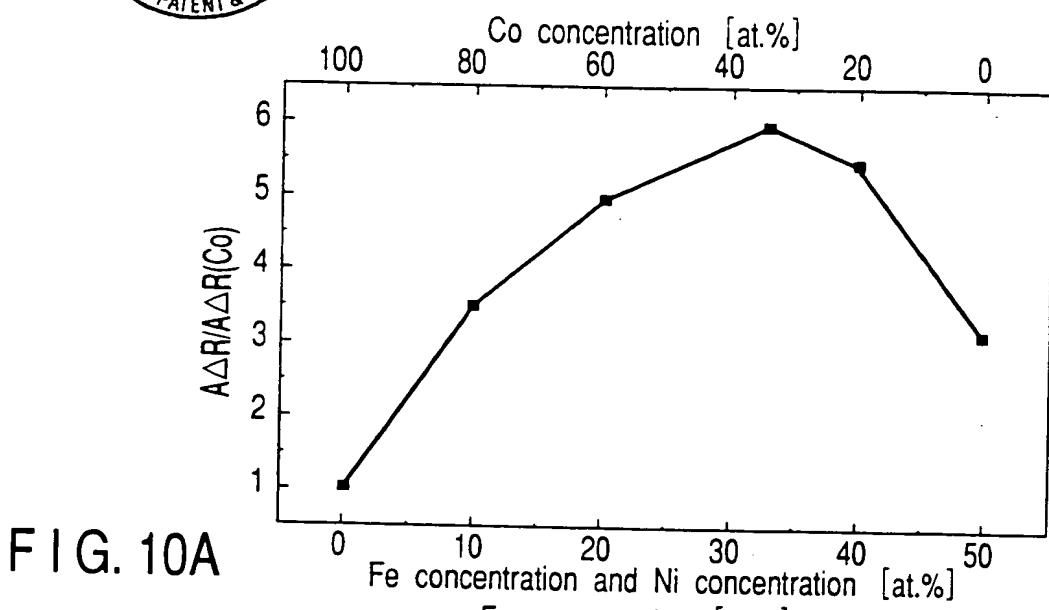


FIG. 11



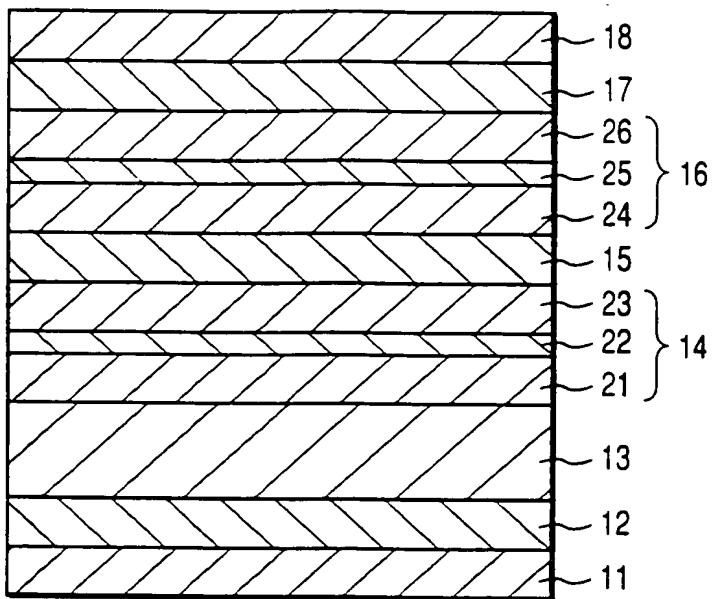
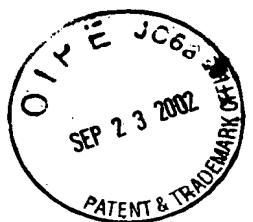


FIG. 12

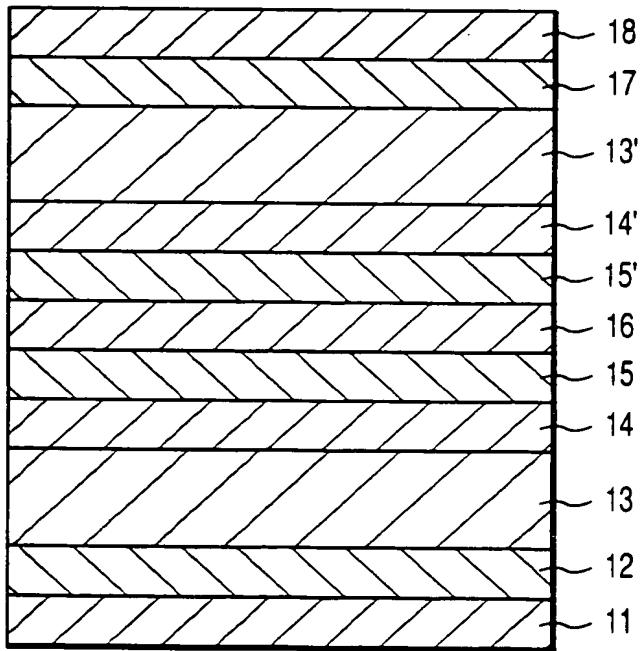


FIG. 13

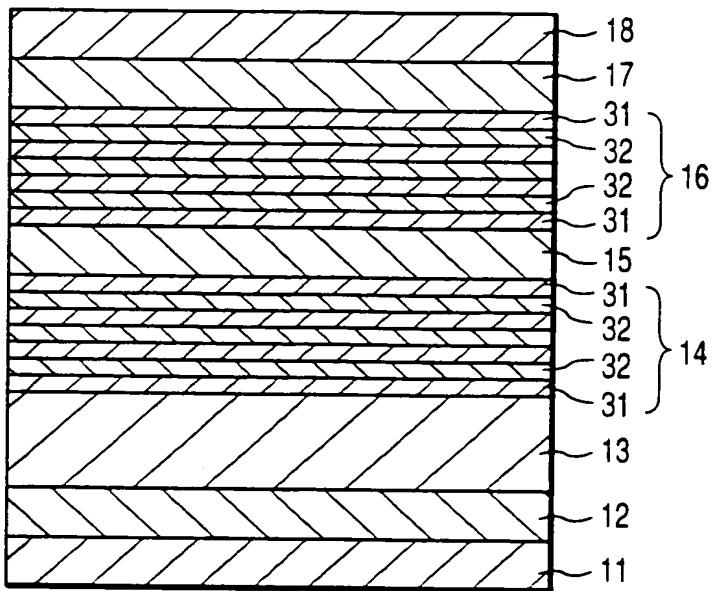


FIG. 14

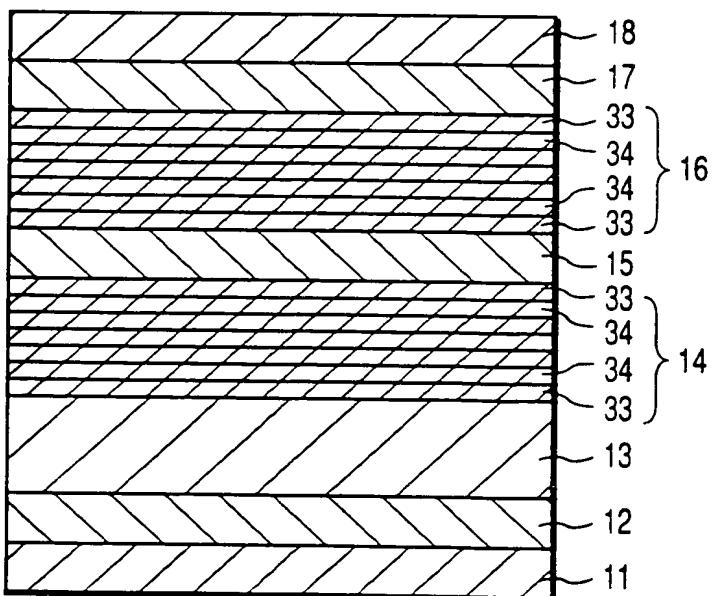


FIG. 15

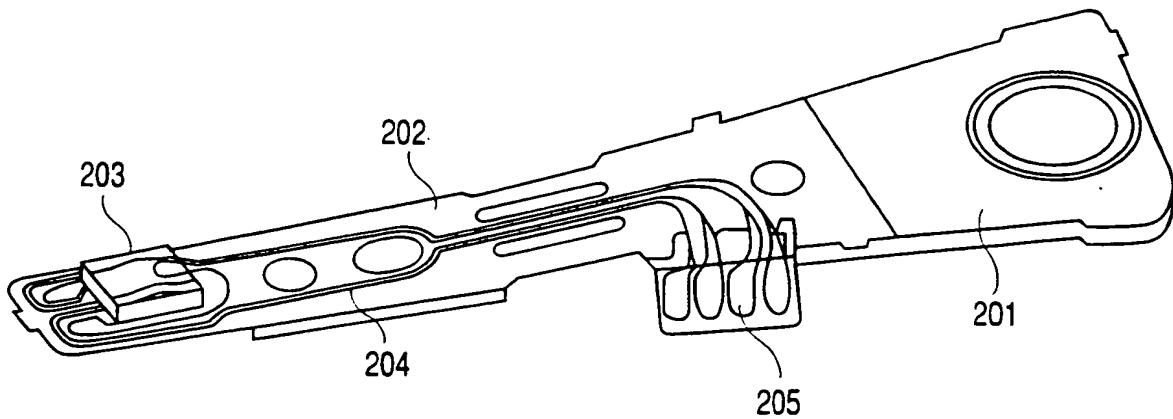
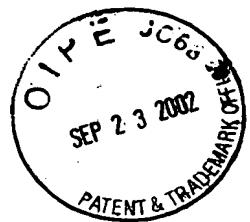


FIG. 16A

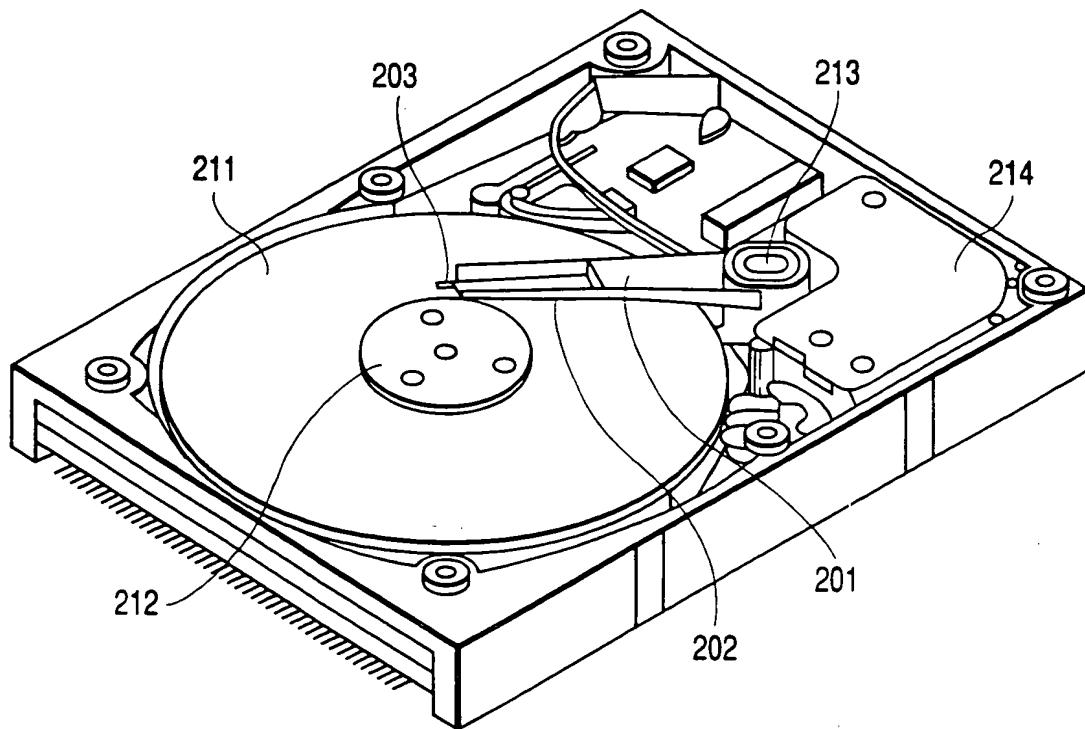


FIG. 16B

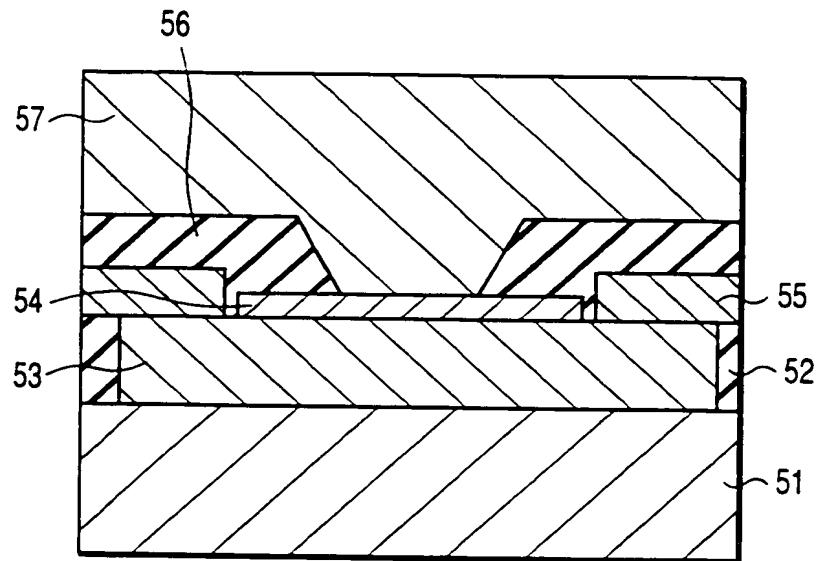


FIG. 17

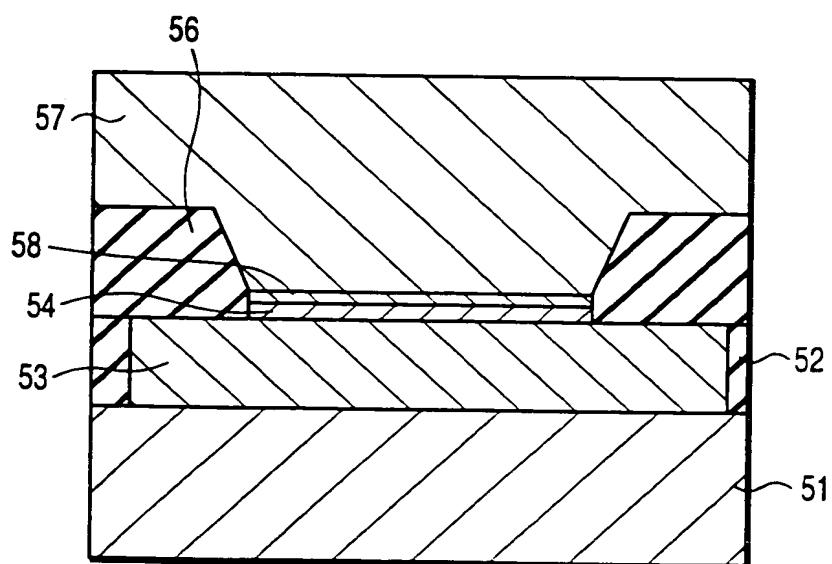


FIG. 18

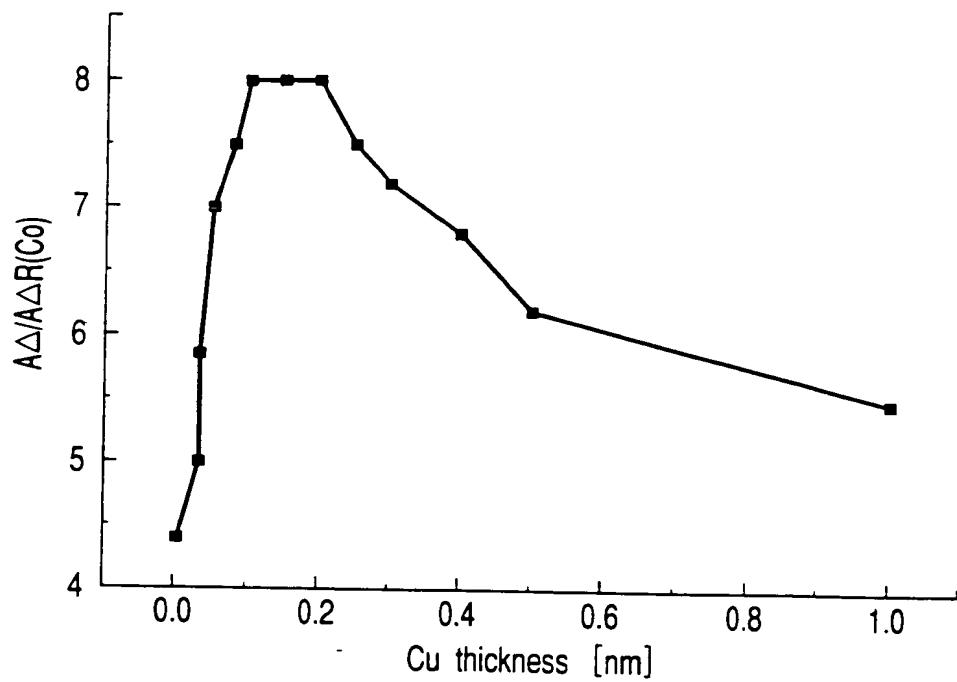
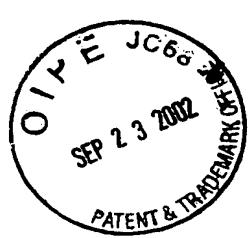


FIG. 19

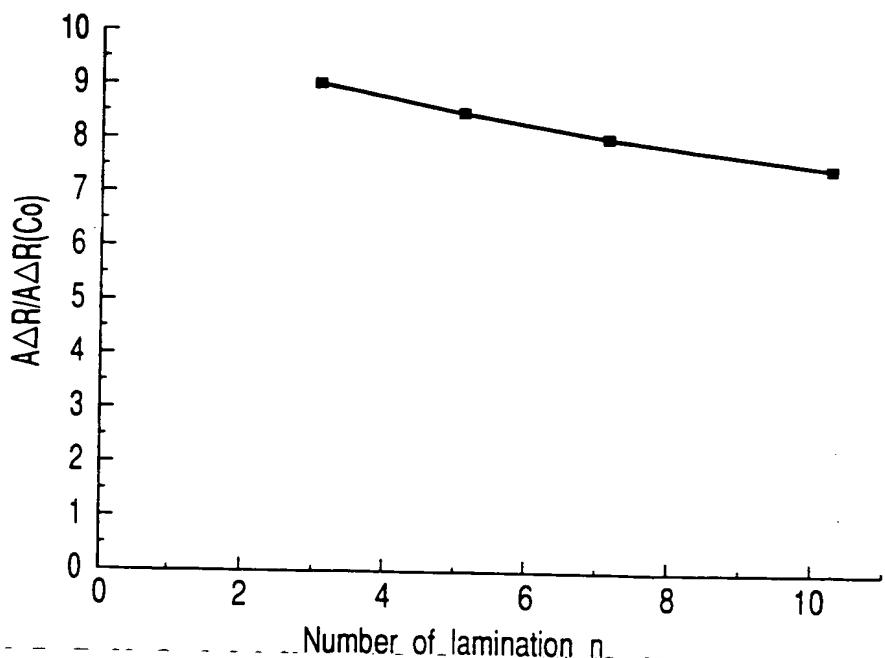


FIG. 22

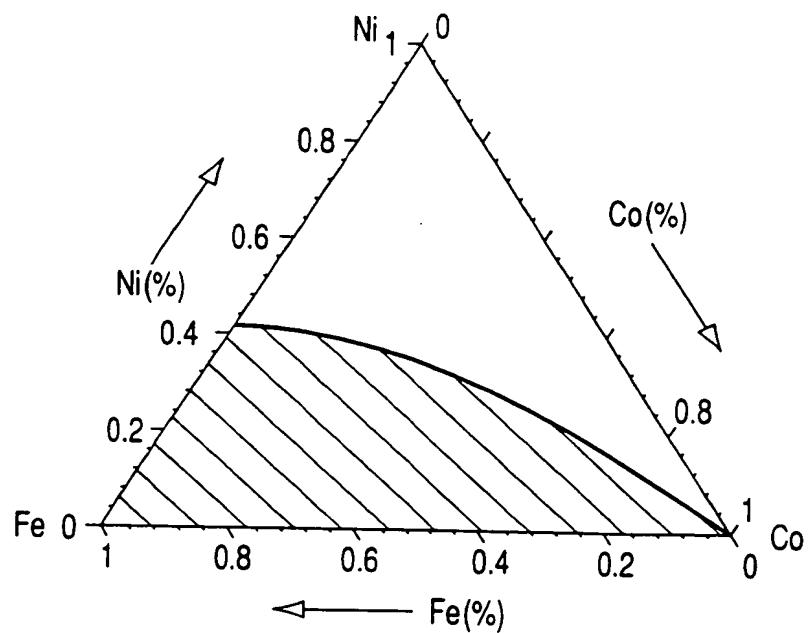
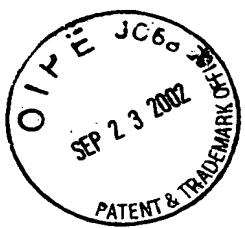


FIG. 20

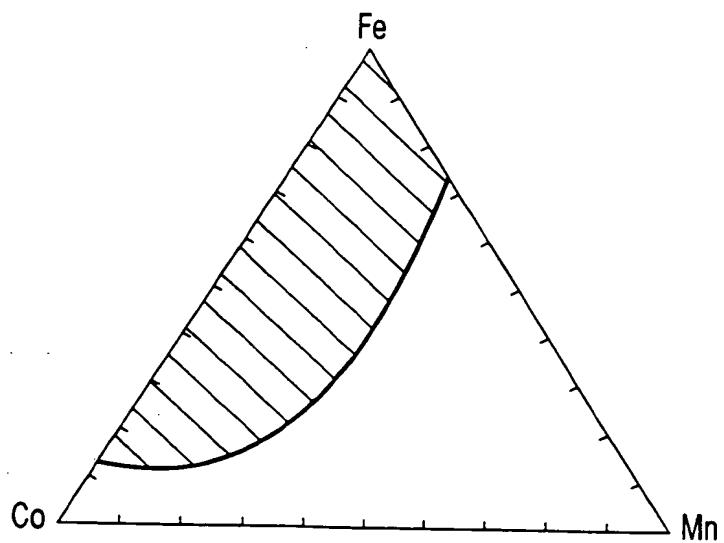


FIG. 21

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